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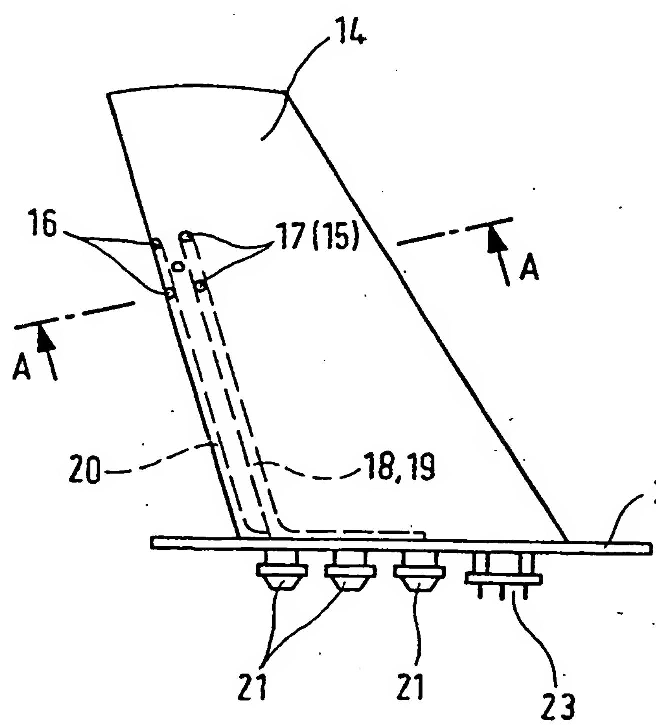
(54) Title: PITOT–STATIC TUBE

(57) Abstract

The invention relates to a Pitot–static tube (14) comprising a body with inlet orifices (15, 16, 17) for determining flow parameters of a surrounding medium, the body comprising a leading edge, a first group of said orifices being provided in the region of said leading edge and a second group of orifices being provided on both an upper and lower surface of said body. Only two groups of orifices are necessary to determine all relevant flow parameters so that the size and aerodynamic drag of the Pitot–static tube can be reduced. Preferably, the cross sections of said body are constructed in the form of an aerodynamic profile.



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Pitot-Static Tube

The invention relates to the determination of the flight parameters of flying vehicles or to other fields of science and technology which deal with flows of liquid and gas.

The measurement of flight parameters is one of the most important problems in the aeromechanics and aerodynamics of flying vehicles (FVs). At the present time, to measure flight parameters (flow parameters) use is made of Pitot-Static tubes (PSTs) which are frequently mounted directly on the fuselage of the aircraft or the body of some other flying vehicle, and which actually measure the parameters of local flow close to a planar flow. As a rule, some of these PSTs which measure local flow parameters are mounted on the flying vehicles. The actual flight parameters are determined on the basis of prior calibrations.

US 4,615,213 teaches a fuselage Pitot-static tube for determining flight (flow) parameters - angle of attack α, total pressure P_0 and static pressure P_s, and consequently, Mach number M, which is an elongated axially symmetric body having a head part in the form of a hemisphere with groups of orifices on the axially symmetric body for measuring pressures, by means of which the flight (flow) parameters are deter-

mined with the aid of calibrations. The orifices for measuring pressures by means of which the total pressure and angle of attack are determined are arranged on the hemispherical head part, while the orifices for measuring static pressure are arranged on the lateral (cylindrical) surface of the axially symmetric body. For the purpose of fastening to the fuselage or body of the flying vehicle, this PST has a strut whose profile has a lenticular cross section.

The disadvantages of the given PST are:

- design complexity;
- increased overall dimensions;
- raised aerodynamic drag;
- increased power required for the heated anti-icing system; and
- increased design weight.

This is determined by the presence inside the axially symmetric body of pneumatic paths which go out from the orifices for measuring total pressure and angle of attack, of a chamber for measuring static pressure, and of electric heaters of the anti-icing system. Moreover, the electric heaters arranged inside the strut of a PST prevent the formation of ice on its leading edge are employed insufficiently effectively, since they heat the strut on which no orifices for measuring pressure are arranged. This leads to a significant rise in weight and the electric power consumed (by approximately 50%).

US 4,378,696 teaches a fuselage PST for determining flight (flow) parameters - angle of attack α, total pressure P_0 and static pressure P_S and, consequently, Mach number M, which is an elongated axially symmetric body with a conical or ogival head part, where orifices for

sensing total pressure are arranged, which merges into a circular cylinder on the surface of which orifices for sensing static pressure are arranged. Furthermore, this cylindrical surface merges into a conical one on which there are arranged orifices for sensing pressure in accordance with which the angle of attack is set, and thereafter into a cylindrical one again. For the purpose of being fastened to the fuselage or to the body of the FV, the Pitot probe has a strut whose cross section has a lenticular profile.

The disadvantages of the given PST are determined mainly by the same factors and are basically the same as those for the Pitot-static tube considered above.

A Pitot-static tube is known including a body in the form of a circular cylindrical rod having inlet orifices situated along the periphery of the section and connected by means of channels to nozzles (Petunin, A.N. Kharakteristiki pnevmometricheskikh priemnikov velichiny i napravleniya skorosti pri bolshikh chislakh M. [Characteristics of head-type probes for the magnitude and direction of velocity at large Mach numbers M]. Moscow, Proceedings of the TsAGI [Central Aerohydrodynamic Institute] 1976, Pub. 1989).

The disadvantages of the given PST are as follows:

- a high aerodynamic drag;
- an increased electric power required for the heated anti-icing system;
- a harmful effect of the separation vortex wake downstream of it on the engine air intake, leading to significant losses in engine thrust; and

- the impossibility of determining static pressure with acceptable accuracy in the range of Mach numbers M > 0.75 as a consequence of the phenomenon of transonic stabilization.

The closest of the known technical solutions is a PST including a body in the form of a cylindrical rod having a flat with inlet orifices arranged along the periphery of the section (Inventor's Certificate N 1723879 USSR. Primnik vozdushnogo davleniya [Pitot-static tube]. Priority of 2 January 1990.

The disadvantages of the given PST are as follows:
- a high aerodynamic drag;
- an increased electric power required for the heated anti-icing system; and
- a harmful effect of the separation vortex wake downstream of it on the engine air intake, leading to significant losses in engine thrust.

The indicated disadvantages are similar to those described above and are determined by the following factors.

1. As is known (see, for example, Shlikhting, G. Teoriya pogranichnogo sloya [Theory of the boundary layer]. Moscow, isd. inostr. lit., 1975), the drag coefficient C_X of such a PST is very high both for subsonic and for supersonic flow regimes, and is close to C_X for a cylinder. Consequently, it is possible to reduce the drag force of its section $X = C_X qS$, where q is the dynamic pressure and $S = hd$ is the area of the cross section of the cylinder, for a given height h of the probe, which is determined by the stagger of the inlet orifices relative

to the boundary layer of the fuselage of the FV only by reducing its diameter d. However, the diameter of a PST mounted on an FV is determined by the diameters of the pneumatic paths, which go out from all the groups of orifices, and also by the diameters of the tubular electric heaters (TEHs) of the anti-icing system. The diameter of the pneumatic paths and the TEHs cannot be less than certain minimum values which are determined for the pneumatic paths by the magnitude of the hydrodynamic lag, and for the TEHs by the heat and temperature flux density of the surface of the electric heaters. As a result of the indicated factors and the high design saturation of the internal volumes of the PST, the diameter of the cylindrical rod cannot be made sufficiently small to significantly reduce the aerodynamic drag of this PST.

2. As is known (see, for example, Bragg M.B., Gregorek G.M., Lee J.D. Airfoil Aerodynamic in Icing Conditions. J. Aircraft, vol. 23, No. 1, 1986), the formation of ice on an FV during flight in the atmosphere occurs, chiefly, in regions adjoining points of flow deceleration and separation, where the flow is also decelerated. Since the frontal surface of a cylinder, where the flow is decelerated, makes up a significant part of the given PST, preventing the formation of ice requires a very significant quantity of thermal energy to be fed to that region. Moreover, since the flow around the leeward part of a given PST always occurs with separation of flow, where it is decelerated, it is also necessary to feed into this region supplementary energy for preventing the formation of ice. For other bodies, where separation is lacking or is not so intensive, these losses of thermal energy can be substantially reduced. At the same time, for design and aerodynamic considerations for a range of FV arrangements, there is a need to mount the PST on the FV upstream of the inlet to the air intake.

3. As is known, mounting even very small bodies or surfaces upstream of the inlet to the air intake of the engine of an FV can lead to very large losses in engine thrust (Zatoloka, V.V., Ivanyushkin, A. K., Nikolaev, A.V. Interferentsiya vikhrei so skachkom uplotneniya v vosdukhozabornike. Razrushenie vikhrei [Interference of vortices with shock waves in an air intake. Destruction of vortices.]. Scientific transactions of the TsAGI, Vol. VI, No. 2, 1975). The cause of this harmful influence consists in the influence of an expanding separation wake from this body or surface on losses in total pressure in the air intake. Although vortices downstream of a given body of a PST are not concentrated, expansion of the wake downstream of such a PST leads nevertheless to appreciable losses in total pressure in the air intake, and, as indicated by experiments, this can lead to a 2-3% loss in engine thrust. There are bodies which can be used as bodies of a PST, where such large losses can be avoided.

The characteristics of the proposed PST permit a reduction in the losses due to the causes enumerated above, when there is no need to carry out direct measurements of total and static pressure.

The technical result is as follows:

- a reduction in aerodynamic drag;
- a reduction in the power required for the anti-icing system; and
- a lowering of the harmful effect on the engine air intakes for PSTs intended for various FVs.

The technical result is achieved by virtue of the fact that the Pitot-static tube comprises a body with inlet orifices for determining flow

parameters of a surrounding medium, the body comprising a round or tapered nose, a first group of said orifices being provided in the region of said nose and a second group of orifices being provided on both an upper and lower surface of said body.

Preferably, to reduce the aerodynamic drag, the cross sections of the body are constructed in the form of an aerodynamic profile.

When the PST is applied at low subsonic speeds or only high supersonic speeds, the orifices for enhancing the sensitivity of the PST to measured parameters, all the inlet orifices can be situated at a distance from the nose of the aerodynamic profile up to its maximum thickness. In another embodiment, the first group of orifices is arranged on the nose of the body. In said embodiment, the second group of orifices is preferably arranged at a distance from the nose of said body up to its maximum thickness.

The pitot-static tube in accordance with the invention does not include a cylinder attached to said body. All orifices for determining flow parameters are arranged on said body. Accordingly, the aerodynamic drag is further reduced.

For the purpose of applying the PST in the case of near-sonic speeds, the aerodynamic profile can have an exit section on which there is arranged at least one additional orifice for pressure tapping which is connected by an additional channel to an additional nozzle. Because of the lack of the phenomenon of transonic stabilization on the exit section on such a PST, it is possible to enhance the accuracy of measurement of static pressure and M number at near-sonic Mach numbers.

The aerodynamic profile can have a rounded leading edge for the purpose of application at subsonic speeds. The result of this is a reduction in aerodynamic drag and a reduction in the power required for the anti-icing system because of the potential possibility, inherent in the given instance, of locating the TEHs directly in the nose of the aerodynamic profile, which is most subject to the formation of ice.

For the purpose of application at supersonic speeds in order to reduce the aerodynamic drag, the aerodynamic profile can have a sharp leading edge.

For the purpose of reducing the losses of the anti-icing system in terms of thermal energy, the electric heaters of the anti-icing system can be offset towards the leading edge of the aerodynamic profile.

For the purpose of reducing the design weight, the Pitot-static tube can be an element of the actual air frame of the FV (for example, of the wing panel, the tail unit etc.).

The leading edge of the body can have a negative and/or a positive sweep, and the orifices for sensing pressures are preferably arranged in a section passing through in the region of the bend in the leading edge of the body.

There is a substantial reduction in aerodynamic drag by virtue of the fact that the sections of the body are constructed in the form of a specialized aerodynamic profile, and not in the form of a cylinder with

a flat as on the prior-art PST. The frontal surface, where the flow is decelerated, is substantially smaller on the aerodynamic profile than on the semicylinder, for which reason there is an appreciable saving (by 25-30%) in the power required for the electric heaters of the anti-icing system. Since there is virtually no separation wake at low (cruising) angles of attack downstream of the aerodynamic profile, while there is a developed separation wake downstream of the semicylinder, the tail part of the aerodynamic profile is thereby virtually not required in feeding heat for preventing the formation of ice, by contrast with the prior-art PST. Thus, according to estimates it is additionally possible to economize by 10-15% of the power required for the anti-icing system. As a result of the lack of a separation wake downstream of the aerodynamic profile in the cruising regime, it has virtually no effect on the operation of the engine air intake.

By virtue of the situation of the inlet orifices at a distance from the nose of the aerodynamic profile up to its maximum thickness, there is an enhancement of the sensitivity of the PST to measured parameters at low subsonic flight speeds or high supersonic speeds.

By virtue of the fact that the aerodynamic profile can have an exit section on which there are arranged orifices for measuring pressure at near-sonic speeds, there is an enhancement of the accuracy of measurement of the static pressure and M number.

By virtue of the application at subsonic speeds of the aerodynamic profile with a rounded leading edge, there is a widening of the operating range of the PST in terms of angle of attack, a reduction in aerody-

namic drag, a reduction in the losses of thermal energy, and also a reduction in its effect on the operation of the engine air intake.

By virtue of the application of the aerodynamic profile with a sharp leading edge, at supersonic speeds there is a substantial reduction in aerodynamic drag, and also a reduction in the influence of the PST itself on the engine air intake.

By virtue of offsetting the electric heaters of the anti-icing system towards the leading edge of the aerodynamic profile, there is a substantial reduction in the losses of thermal energy, and consequently a lowering of the required power, since in this instance the electric heaters directly heat the zone most subject to icing - the nose of the aerodynamic profile.

By virtue of the construction of the pressure probe in such a way that its body is an element of the actual air frame of the FV (for example, of the wing panel), it is possible to reduce the aerodynamic drag, the harmful effect on the engine air intake, and also to lower the design weight somewhat.

The invention will now be described by way of examples with reference to the accompanying drawings, in which:

Figure 1	shows a side view of a first embodiment of a PST in accordance with the invention in the form of a half-wing with negative sweep;
Figure 2	shows a top view of the PST according to Figure 1;
Figure 3	shows a section along line A-A in Figure 1;

Figure 4 shows a side view of a second embodiment of a PST in accordance with the invention in the form of straight half-wing with zero sweep along the leading and trailing edges;

Figure 5 shows a top view of the PST according to Figure 4;

Figure 6 shows a section along line A-A in Figure 4;

Figure 7 shows a side view of a third embodiment of a PST in accordance with the invention in the form of a half-wing with positive sweep along the leading and trailing edges;

Figure 8 shows a top view of the PST according to Figure 7;

Figure 9 shows a section along line A-A in Figure 7;

Figure 10 shows a side view of a forth embodiment of a PST in accordance with the invention with positive and negative sweep along the leading edge;

Figure 11 shows a top view of the PST according to Figure 10;

Figure 12 shows a section along line A-A in Figure 10;

Figure 13 shows a side view of a fifth embodiment of a PST in accordance with the invention with positive and negative sweep along the leading edge optimized for mounting on a main-route medium class passenger aircraft;

Figure 14 shows a top view of the PST according to Figure 13;

Figure 15 shows a section along line A-A in Figure 13;

Figure 16 shows a side view of a sixth embodiment of a PST in accordance with the invention with positive and negative sweep along the leading edge;

Figure 17 shows a top view of the PST according to Figure 16;

Figure 18 shows a section along line A-A in Figure 16;

Figures 19 to 26 show different variants of profiles of the cross section of the PST in accordance with the invention;

Figure 27 shows a side view of a seventh embodiment of a PST in accordance with the invention with an aerodynamic profile having an exit section on which there is an additional orifice for pressure tapping;

Figure 28 shows a top view of the PST according to Figure 27;

Figure 29 shows a section along line A-A in Figure 27;

Figure 30 shows a side view of a eighth embodiment of a PST in accordance with the invention with an aerodynamic profile having TEHs offset towards the leading edge of the aerodynamic profile

Figure 31 shows a top view of the PST according to Figure 30;

Figure 32 shows a section along line A-A in Figure 30;

Figure 33 presents an example of the functional relationship of the calibration angle; and

Figure 34 shows the variation in the ratio P_{15}/P_{16} with the Mach number.

The Pitot-static tube comprises a body 14 having inlet orifices 15, 16, 17 distributed along the periphery of the section and connected by pneumatic paths 18, 19, 20 to nozzles 21, and having electric heaters 22 of an anti-icing system, which are arranged inside the body 14 and are supplied with power via an electric connector 23. The sections of the body 14 are constructed in the form of an aerodynamic profile. The Pitot probe is fastened to the fuselage with the aid of a flange 24.

The Pitot-static tube operates in the following way.

The different pressures P_{15}, P_{16}, P_{17} sensed by the inlet orifices 15, 16, 17 are transmitted via nozzles 21 to a transducer unit which converts the pressures into electric signals. These electric signals are sent to an information processing unit in which the flow (flight) parameters P_0, P_S, M, α are determined from calibration relationships. Electric energy is fed to the electric heaters 22 via an electric connector 23 in order to prevent the formation of ice which can strongly distort the measurement or lead to failure of the PST. The electric heaters 22 heat the external shell of the body 14, and also the pneumatic paths 18, 19, 20 which are, as a rule, produced from materials (for example, nickel) which are extremely good thermal conductors. The power of the electric heaters and of the electric energy fed is selected so as to prevent the formation of ice on the surfaces of the body 14, in orifices 15, 16, 17 and in pneumatic paths 18, 19, 20.

For the purpose of enhancing the sensitivity of the measured pressures, and thereby to enhance the accuracy, the inlet orifices 15, 16, 17 can be located at a distance X_C from the nose of the aerodynamic profile up to its maximum thickness C (Figure 19).

For the purpose of enhancing the accuracy of measurement of the static pressure at near-sonic Mach numbers and, at the same time, to lower the shock-wave drag, the aerodynamic profile can have an exit section 25 (Figure 27 to 29) on which there are arranged additional orifices 26 connected by additional channels 27 to an additional nozzle 28.

For the purpose of additionally lowering the aerodynamic drag at subsonic speeds, the aerodynamic profile of the body 14 can have a rounded leading edge (Figures 19 to 21).

For the purpose of additionally lowering the aerodynamic drag at supersonic speeds, the aerodynamic profile of the body 14 can have a sharp leading edge (Figures 22 to 26).

For the purpose of additionally reducing the power required for the anti-icing system, the electric heaters 22 of the anti-icing system can be offset towards the leading edge of the aerodynamic profile (Figures 27 to 32).

For the purpose of additionally reducing the aerodynamic drag and lowering the harmful effect on the engine air intake, and also lowering the weight, the body 14 of the Pitot-static tube can, when permitted by the design of the FV, be an element of the actual air frame proper of the flying vehicle, as shown in all embodiments.

For the purpose of additionally widening the range of angles in which linear laws are realized for the variation in the difference between pressures in terms of the angle of attack, the body of the proposed PST can be constructed with a negative and positive sweep along the leading edge, and the section in which there are orifices for measuring pressures can pass through the point of the bend in the leading edge.

A variant of the embodiment of the proposed PST which is optimized for mounting on a main-route medium class aircraft is represented in Figure 13.

The relevant flow parameters are calculated by means of the following equations:

Average Static Pressure $= (P_{17} + P_{15})/2$

Average Q_c $= P_{16}$ - Average Static Pressure

$\chi_\alpha = (P_{17} - P_{15})/Q_c$

Based on said equations, calculation of the flow parameters is achieved by suitable calibration functions which are known to a preson skilled in the art and will therefore not be described in detail. P_i refers to the specific orifice inquestion, i.e. P_{17} is the pressure determined by orifice 17.

Figure 33 presents an example of the functional relationship of the calibration slope χ_α as set forth above for determining the angle of attack for the proposed PST, and also for the prior-art PST, for which the orifices for determining the angle of attack are arranged on a conical part of an axially symmetric body.

Figure 34 shows the variation with Mach number in the ratio P_{15}/P_{16} of the pressures measured correspondingly; P_{15} on the surface of the PST at a distance from its leading egde, P_{16} in the leading edge region of the PST and the variation in Mach number of the ratio P_{26}/P_{16}, where P_{26} is the pressure in the exit region of the aerodynamic profile of the strut.

The following can be achieved by using the invention:

- a reduction in aerodynamic drag;
- a reduction in the power required for the anti-icing system; and

- a lowering of the harmful effect on the engine air intake.

Let us demonstrate this.

1. As is known, the drag coefficient C_X of a cylinder or semicylinder (see, for example, Hoerner S.F. Fluid-dynamic drag. Published by the Author, 1965) as a function of the flow regime is one hundred or more times higher than that of an aerodynamic profile for an angle of attack close to zero. In this case, the diameter d of a cylinder or semicylinder is adopted as its characteristic dimension, while it is the chord b which is adopted as the characteristic dimension for the aerodynamic profile. As design studies show, when pneumatic paths and electric heaters of an anti-icing system of such a diameter are located in the proposed PST, as in the prior-art PST, the aerodynamic chord b of the profile of the cross section must be approximately 3 times larger than the diameter d of the prior-art PST. The force of aerodynamic drag in a cruising flight regime (for an angle of attack close to zero) can be represented in the form of $X = C_X qS$, where $S = dh$ is the characteristic area for the PBD of the example of the prior art, $S = bh$ is the characteristic area for the proposed PST, h is the height of the PST, and q is the dynamic pressure. Consequently, the aerodynamic drag force of the proposed PST is 30 or more times less than the drag force of the prior-art PST for the same magnitude of dynamic pressure q. An additional reduction in the drag coefficient C_X, and thus in the force X may be achieved at subsonic speeds by applying a specialized aerodynamic profile with a rounded leading edge, and at supersonic speeds by using one with a sharp leading edge. Moreover, at numbers of $M = 0.8\text{-}0.9$ it is possible to achieve a substantial reduction in the component of shock-wave drag by means of reducing the diffuser action in the region of the trailing edge, and moving the

shock wave away towards the trailing edge owing to the presence of a certain exit section on the aerodynamic profile. As calculations show, the drag coefficient C_X can thus be lowered by 2-2.5 times by comparison, for example, with the customary lenticular aerodynamic profile. It is entirely evident that in the case when the body of the proposed PST is an element of the actual air frame proper of the FV (for example, a wing panel or tail unit), there is no additional aerodynamic drag.

2. The frontal surface, where flow deceleration occurs, is substantially (several times) reduced on the proposed PST by comparison with the prior-art PST at cruising angles of attack, for $\alpha \approx 0$. Moreover, for an aerodynamic profile with a sharp trailing edge there is no flow separation at cruising angles of attack or at all, or the zone of flow separation, where the flow is decelerated, is very small for an aerodynamic profile with an exit section by comparison with the exit region of the prior-art PST. Consequently, as estimates indicate, the power required for the anti-icing system of the proposed PST by comparison with the prior-art PST can be reduced by 25-30%. An additional lowering of the power (by approximately 10-15%) can be achieved by offsetting the electric heaters towards the leading edge of the aerodynamic profile.

3. In the case of cruising flight regimes, a separation wake which can fall into the engine air intake and cause losses in total pressure there leading to corresponding losses in engine thrust is virtually lacking on the proposed PST with an aerodynamic profile with a sharp trailing edge. According to existing estimates for such a variant of the proposed PST, the losses in engine thrust can be reduced by 15-20

times by comparison with the prior-art PST. For the case when use is made in the proposed PST of an aerodynamic profile with an exit section, there is downstream of it a certain separation wake which can, upon falling into the engine air intake, lead to certain losses in total pressure in the air intake, and to corresponding losses in engine thrust. However, since this separation zone downstream of the proposed PST is substantially smaller than downstream of the prior-art PST, these losses are still less than in the case of the presence of the prior-art PST. Estimates show that in this case the losses in engine thrust can be reduced by 8-10 times by comparison with the prior-art PST. Clearly, the losses in engine thrust will no longer be present from the mounting of the PST when the body of the PST is an element of the actual air frame proper of the flying vehicle.

4. An increase in the accuracy of measurement of the angle of attack on the proposed PST by comparison with the prior-art PST is achieved as a result of the fact that the orifices for tapping pressures by means of which the angle of attack is determined are arranged on a strut having cross sections in the form of an aerodynamic profile, and not on the conical part of the axially symmetric body. It may be seen from the functional relationships, represented in Figure 33, of the slope (α), which are obtained on the basis of experimental data, that the derivative for the orifices on the aerodynamic profile in the range of angles of attack of $\alpha = 0\text{-}20°$ is substantially ($\approx$ 5 times) greater than for the orifices arranged on the conical surface of the axially symmetric body of the prior-art PST. The error in the determination of the angle of attack can be written in the form of $\delta\alpha = d\alpha/d\chi_\alpha * \delta p/q$, where q is the dynamic pressure and δp is the error in the measurement of the pressure difference $P_{17}\text{-}P_{15}$. Thus, for an error in real pressure transducers

of $p = 0.15$ mm mercury column with $M = 0.2$, the error in the measurement of the angle of attack in the indicated range of angles of attack has a magnitude of 0.08° on the proposed PST, but of 0.4° for the prior-art PST. Thus, the accuracy of determination of the angle of attack rises by 5 times for the proposed PST.

5. Since it is possible on the proposed PST to select the base pressure from the side of the exit section of the aerodynamic profile of the strut, while the base pressure is a monotonic function of the Mach number and is not subject to the phenomenon of transonic stabilization (compare the character of the changes in the magnitudes P_{26}/P_{16} and P_{15}/P_{16} in Figure 34), it is possible, as experiments show, to enhance the accuracy of measurement of static pressure for $M \approx 1.0$ in the given variant of the proposed PST.

Thus, the given results of calculated estimates and preliminary design and planning studies graphically show the advantages with respect to all the parameters and properties, indicated above, of the proposed PST by comparison with the prior-art PST.

Since, as a rule, there are several such PSTs on an FV, this leads to an appreciable lowering of the aerodynamic drag, a saving in the electric energy consumed, and a reduction in engine thrust losses. All this renders it possible to substantially increase the competitiveness of the proposed Pitot-static tube.

PATENT CLAIMS

1. Pitot-static tube comprising a body with inlet orifices for determining flow parameters of a surrounding medium, the body comprising a leading edge, a first group of said orifices being provided in the region of said leading edge and a second group of orifices being provided on both an upper and lower surface of said body.

2. Pitot-static tube according to Claim 1, characterized in that the cross sections of the body are constructed in the form of an aerodynamic profile.

3. Pitot-static tube according to Claim 1 or 2, characterized in that all orifices are arranged at a distance from the leading edge of said body up to its maximum thickness.

4. Pitot-static tube according to Claim 1or 2, characterized in that said first group of orifices is arranged on said leading edge.

5. Pitot-static tube according to Claim 4, characterized in that said second group of orifices is arranged at a distance from the leading edge of said body up to its maximum thickness.

6. Pitot-static tube according to any preceding claim, characterized in that all orifices for determining flow parameters are arranged on said body.

7. Pitot-static tube according to any preceding Claim, characterized in that said body has a exit section on which there is arranged at least one additional orifice for pressure tapping which is connected to an additional channel to an additional nozzle.

8. Pitot-static tube according to any preceding Claim, characterized in that said body is provided with a rounded or a sharp leading edge.

9. Pitot-static tube according to any preceding Claim, characterized in that electric heaters of an anti-icing system are offset towards the leading edge of said body.

10. Pitot-static tube according to any preceding Claim, characterized in that said body is an element of the actual air frame proper of the flying vehicle.

11. Pitot-static tube according to any preceding Claim, characterized in that the leading edge of the body has a negative and/or a positive sweep, and the orifices for sensing pressures are arranged in a section passing through in the region of the bend in the leading edge of the body.

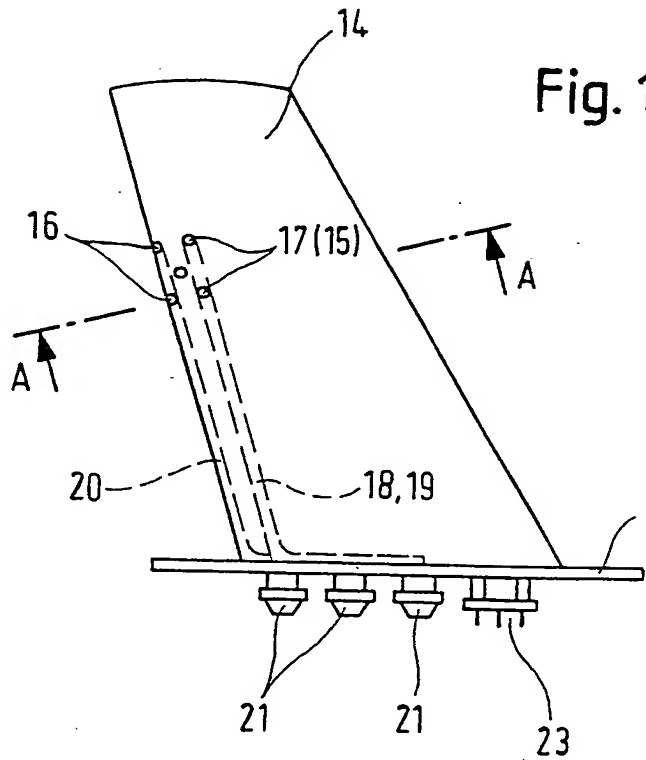
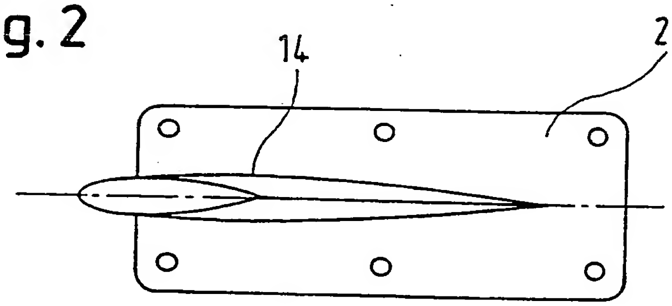


Fig. 1

Fig. 2



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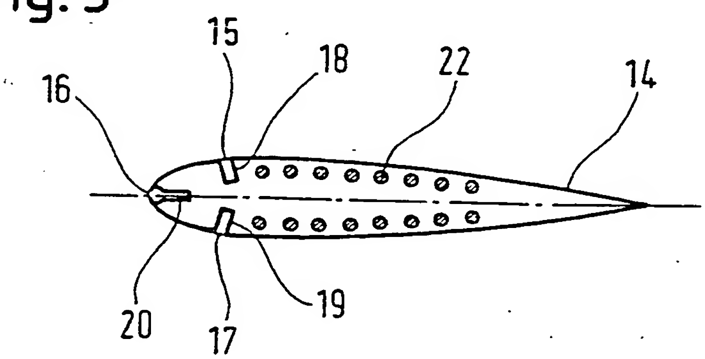

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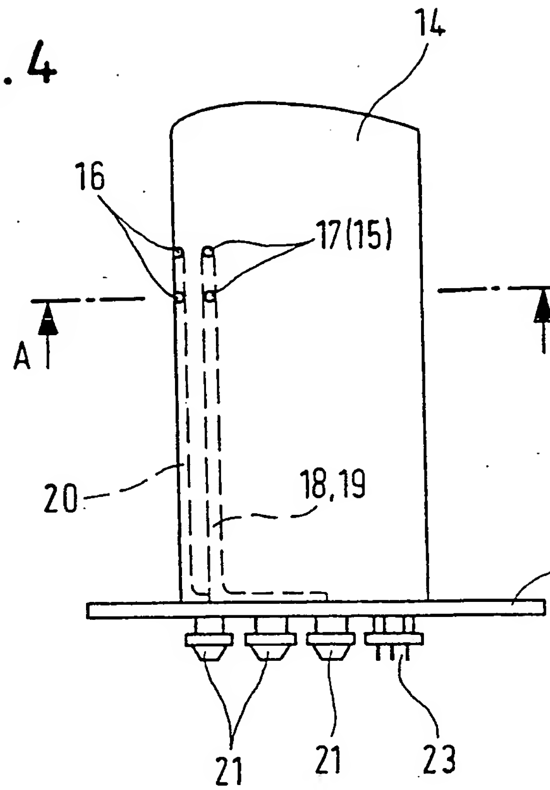

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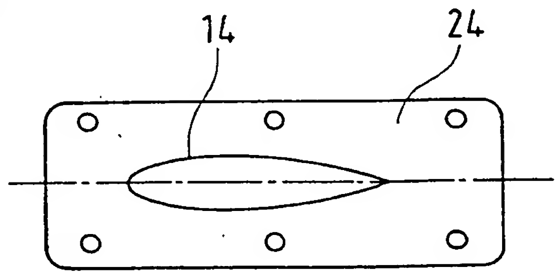

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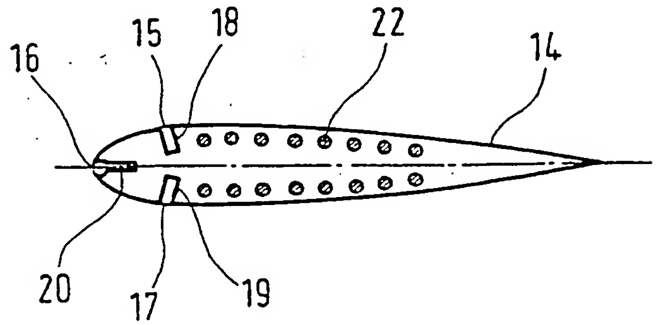

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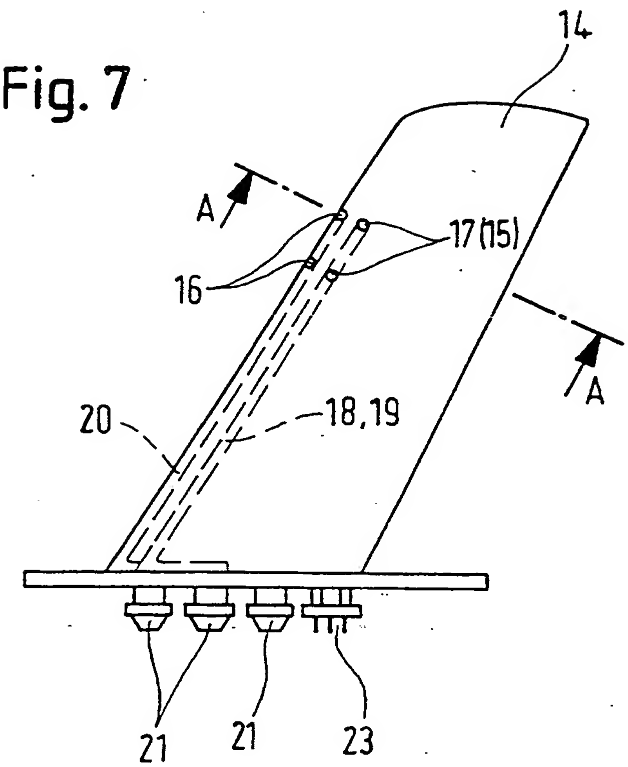
Fig. 7



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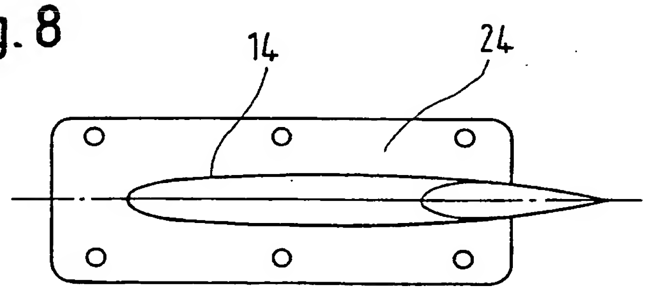

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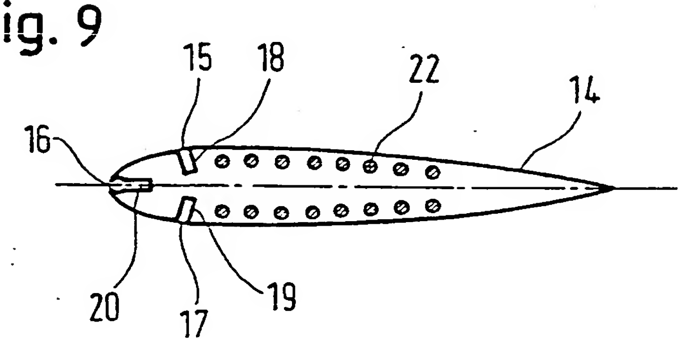

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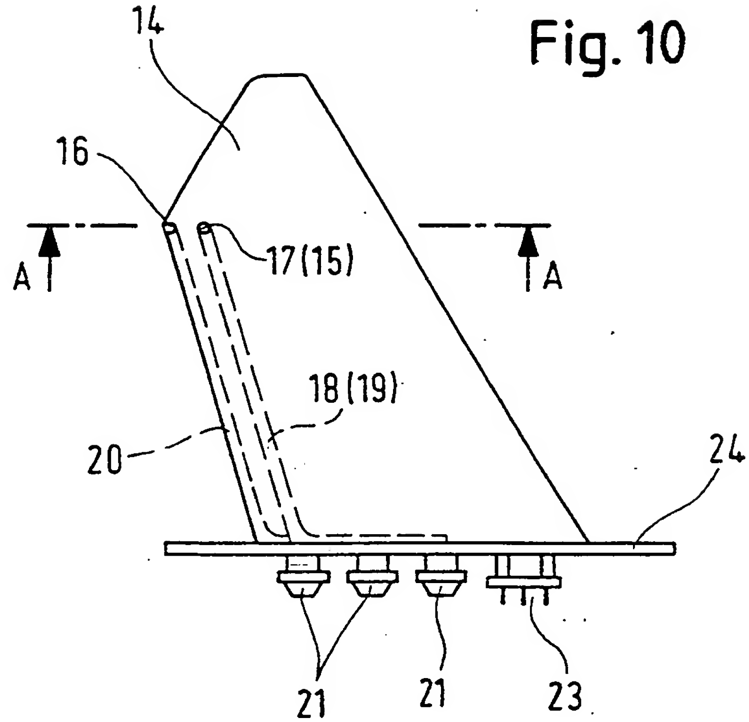

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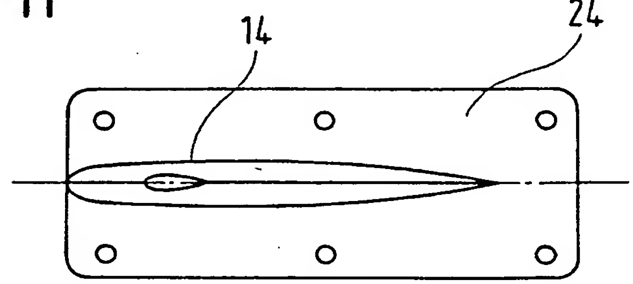

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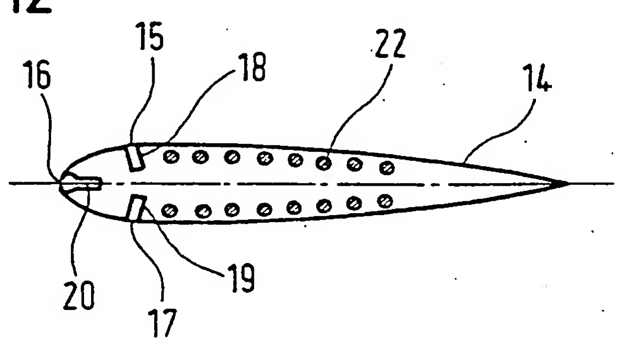

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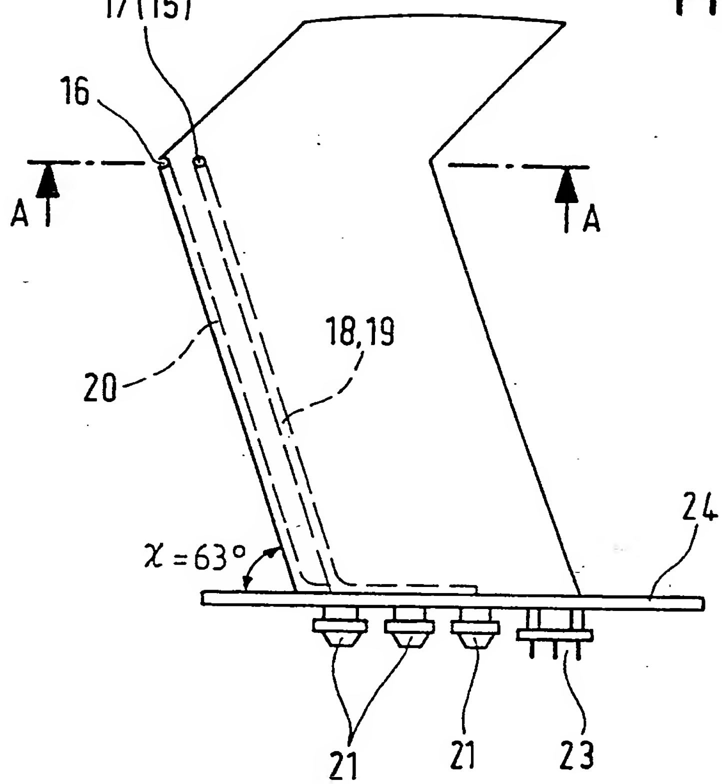

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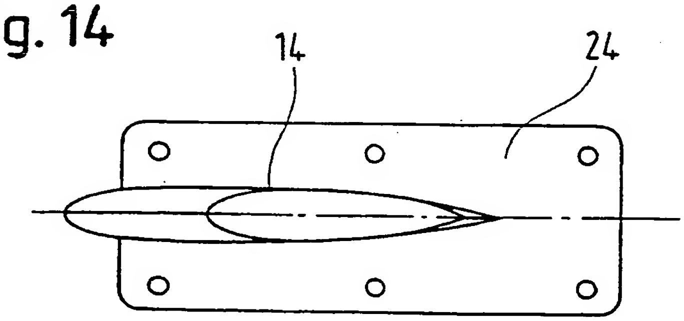

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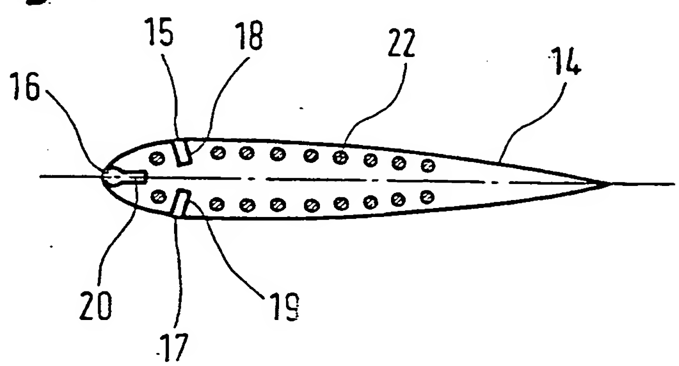

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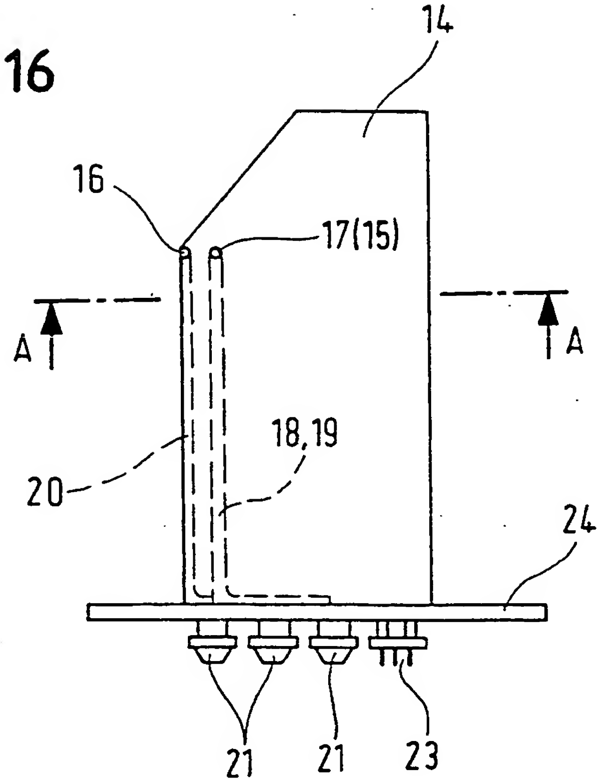

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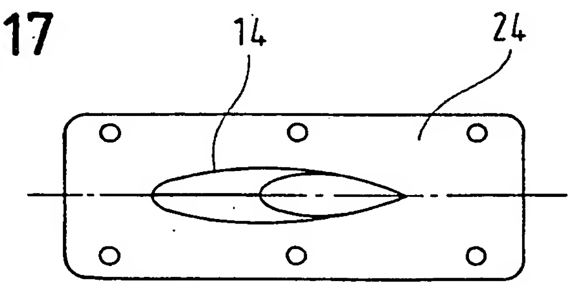

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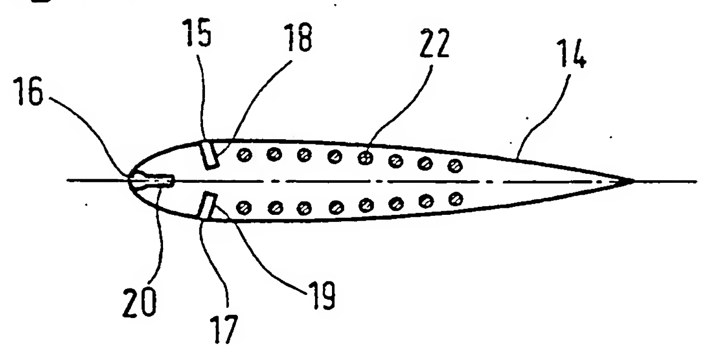

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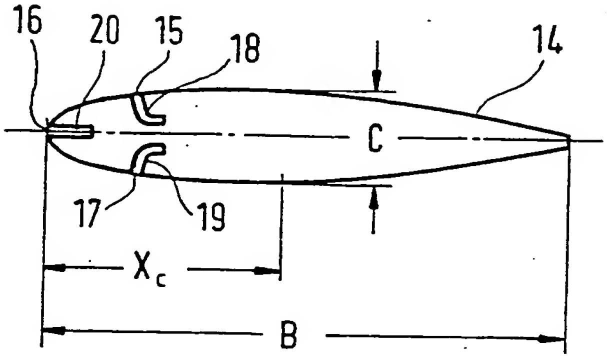

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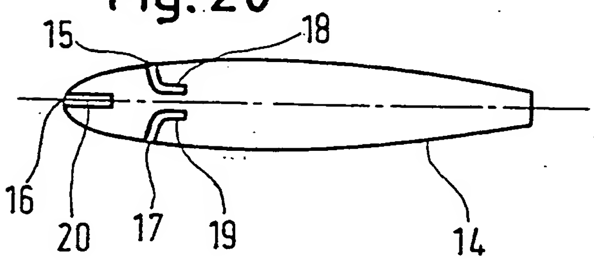

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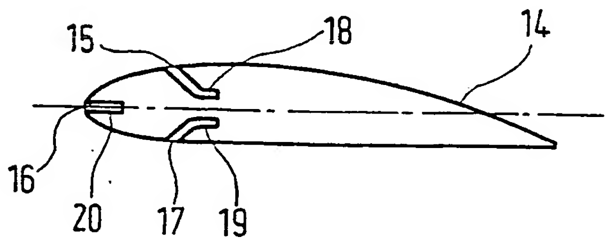

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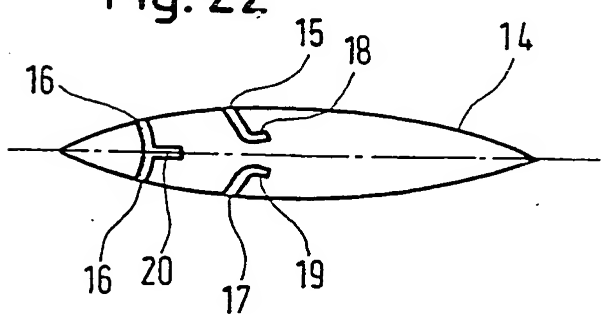

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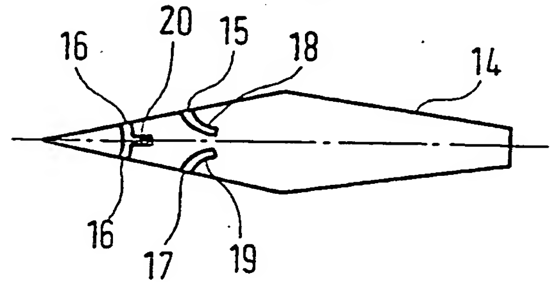

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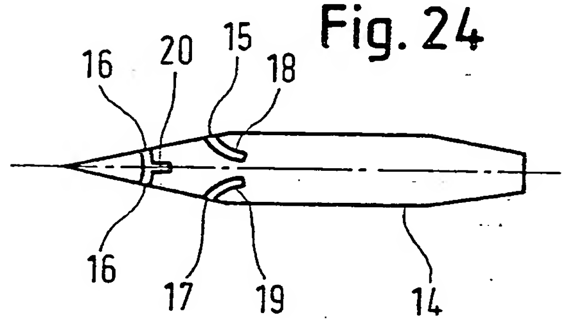

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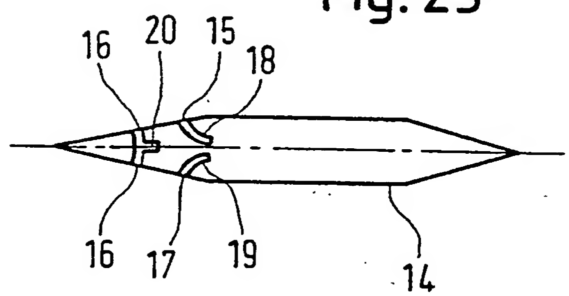

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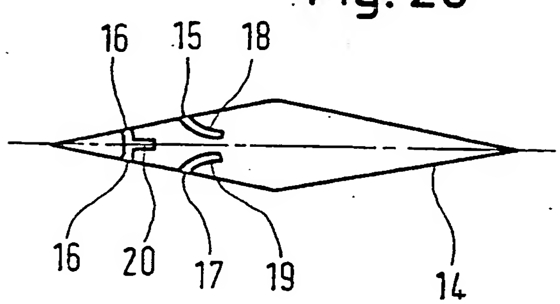


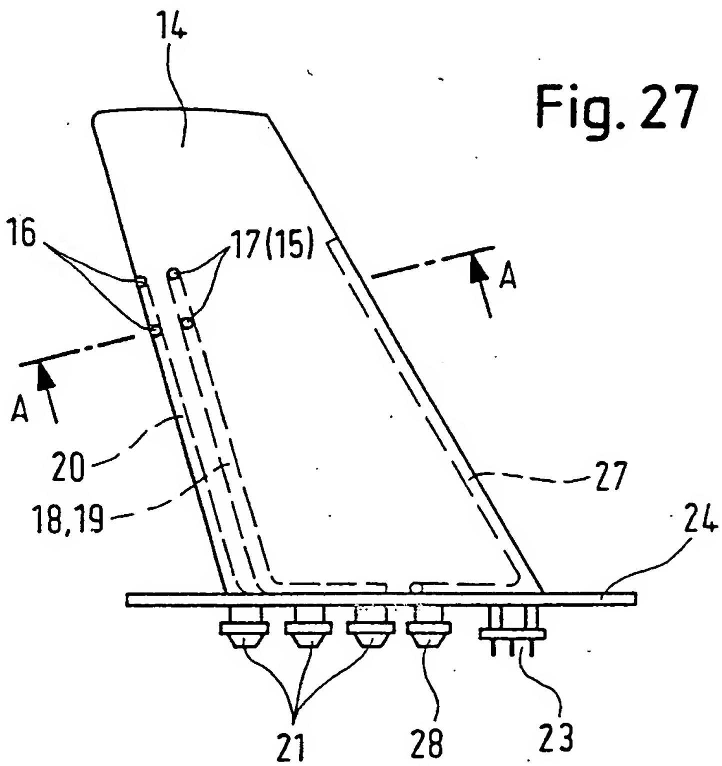
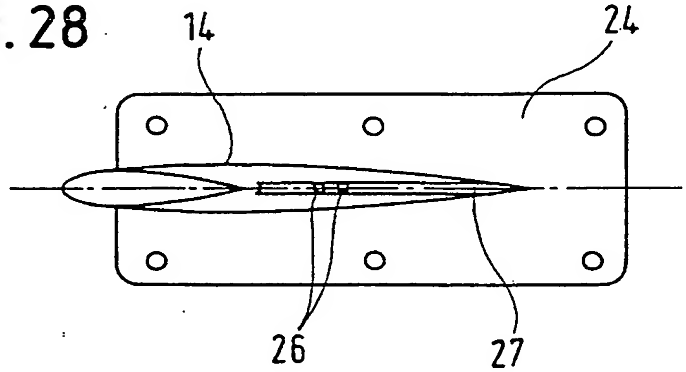


Fig. 27

Fig. 28



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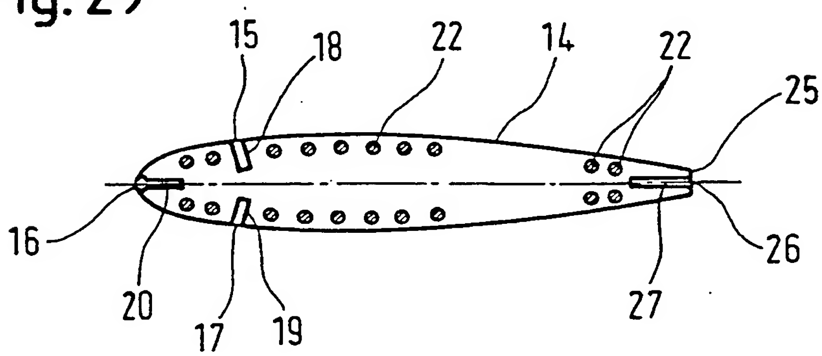

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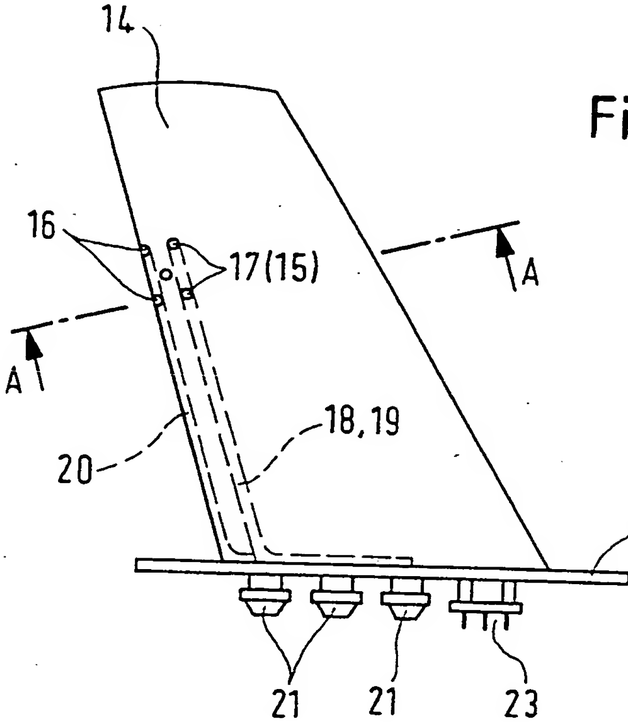

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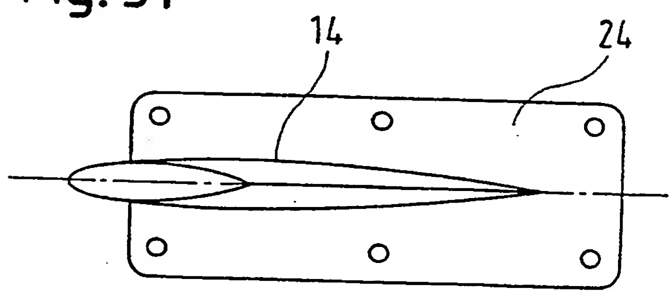

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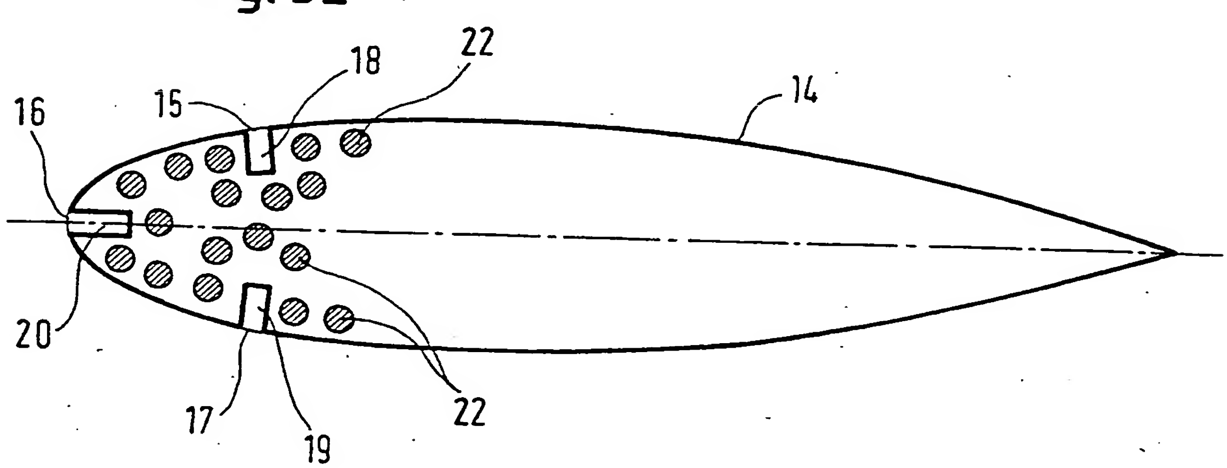

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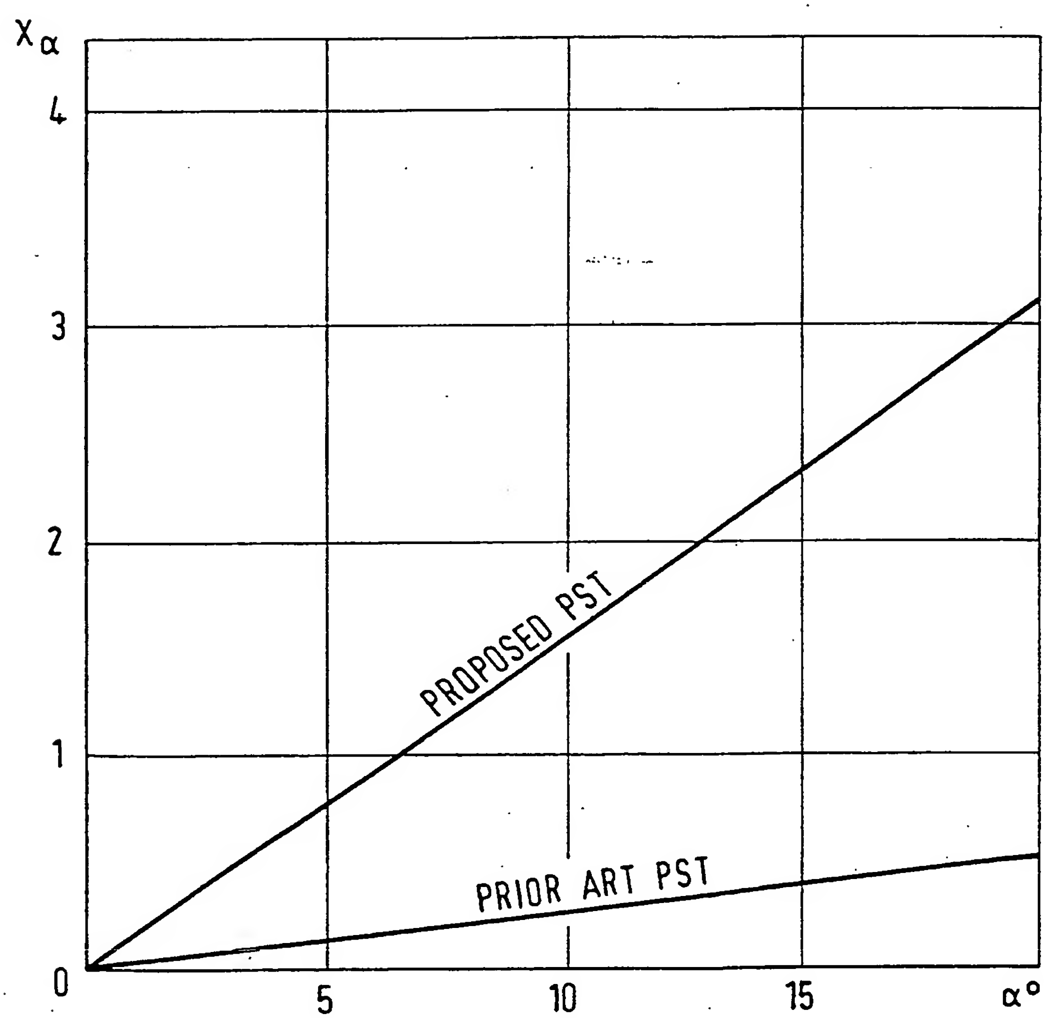
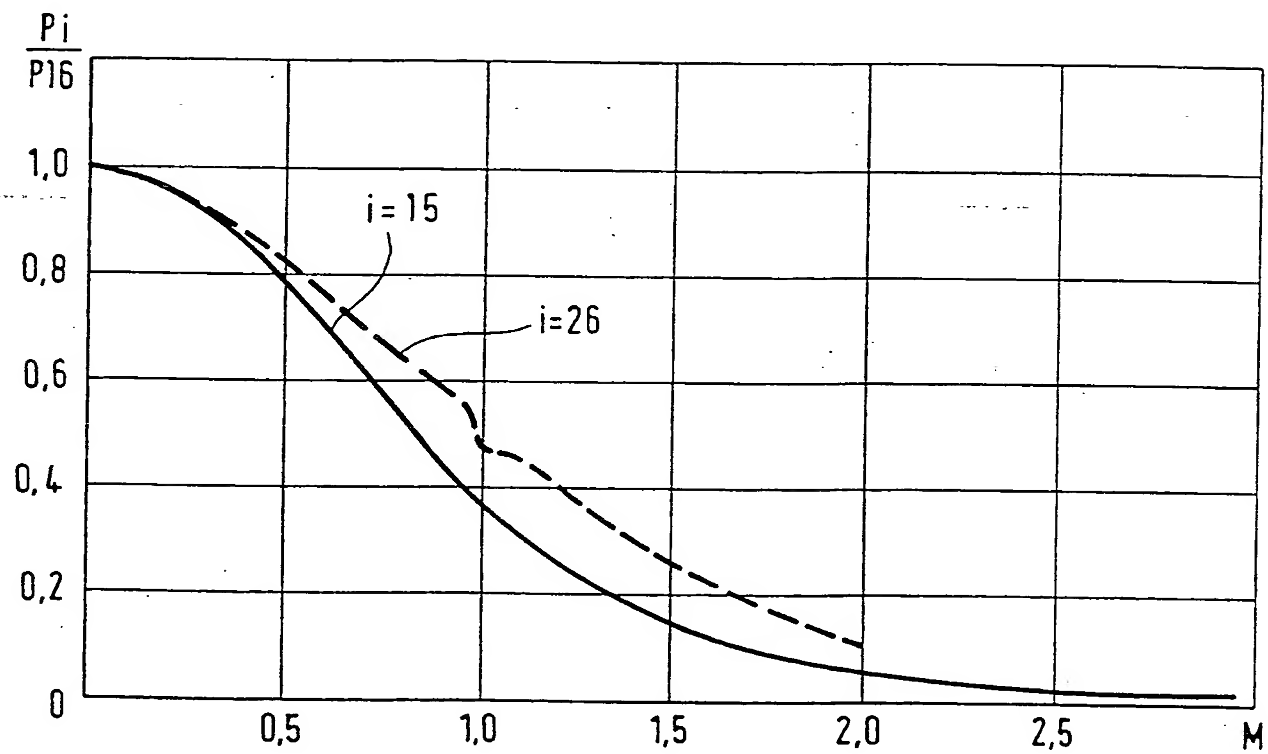


Fig. 34



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 99/03631

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01P13/02 G01P5/165 B64D43/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01P B64D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 469 991 A (SEXTANT AVIONIQUE) 5 February 1992 (1992-02-05) column 2, line 55 -column 3, line 9; figure 1	1-6,8, 10,11
X	US 4 768 386 A (TADDEO JOHN) 6 September 1988 (1988-09-06) column 3, line 15 - line 41	1,2,4,6, 8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 September 1999	28/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pflugfelder, G

INTERNATIONAL SEARCH REPORT

Inf. ation on patent family members

International Application No
PCT/EP 99/03631

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0469991 A	05-02-1992	FR 2665539 A	07-02-1992
		DE 69108135 D	20-04-1995
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